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WAVE TRANSFORMATION AND DISPERSION WITH SPECIAL REFERENCE TO THE POST BREAKING ZONE

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1. Introduction

Mechanisms of energy dissipation processes in surf zones are discussed since the beginning of research work by coastal engineers. Most estimates have been performed on the influence of the bottom friction effect until Führböter (1970) allotted superiority to the formation of the water-air mixture accompanying the wave breaking process. The author's finding of an *anomalous* dispersion property especially in the very shallow portion of the surf zone (Büsching 1978) indicated, however, an additional *absorption* effect. Although, for instance, the phenomenon of refraction according to Snell's law (applying a *relative refractive index*) is generally accepted, mechanisms known from sound and electromagnetic waves hardly ever have been adopted for the description of energy dissipation processes in the surf zone.

2. Absorption and Dispersion of Electromagnetic Waves

From electromagnetic waves it is well known that an *anomalous* dispersion of frequency components is due to a resonance phenomenon. If one has an electromagnetic wave propagating through a medium made up of a number of oscillators (electrons or ions) per unit volume one gets a *complex refractive index*

$$n^* = n - i \cdot k$$

in which n is the real refractive index (also representing phase velocity) and $k = n \cdot \chi$ is an absorption quantity (also representing the amplitude response near resonance).

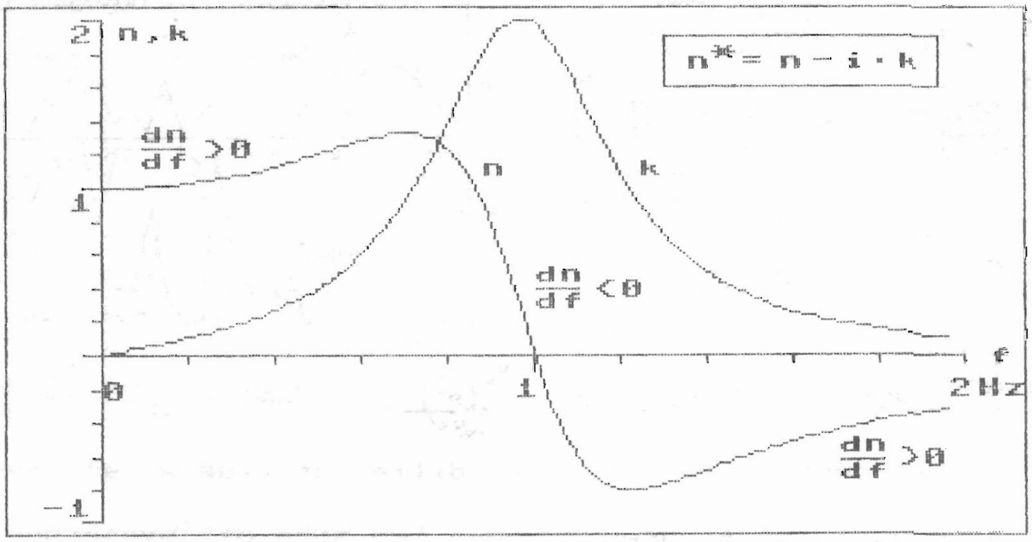


Fig.01: Absorption above and below a region of anomalous dispersion centered about a resonance frequency f = 1 Hz.

Both components vary with wave length and frequency. By the above equation it is stated that resonance, absorption and *anomalous*

dispersion are combined effects.
If an incident component wave has nearly the same length or frequency as an oscillator of the medium resonance occurs. The oscillator absorbs the energy from the forcing incident wave. At resonance absorption - represented here by k - is a maximum, and in the vicinity of the resonance frequency always an *anomalous* dispersion $dn/df < 0$ corresponding to $dc/df > 0$ and $dc/dL < 0$ appears, see Fig.01.
Due to Doppler's spreading effect caused by the irregular movement of atoms and molecules, in liquids and solids the absorption and dispersion curves become very much broadened.

3. Analogous Dispersion of Surf Waves and Electromagnetic Waves

Some indications of an analogue behaviour of surf zone waves could be detected from frequency domain storm surge field data as well as from time domain field data, both with respect to the post breaking zone. The findings are summerized by explaining the following figures.

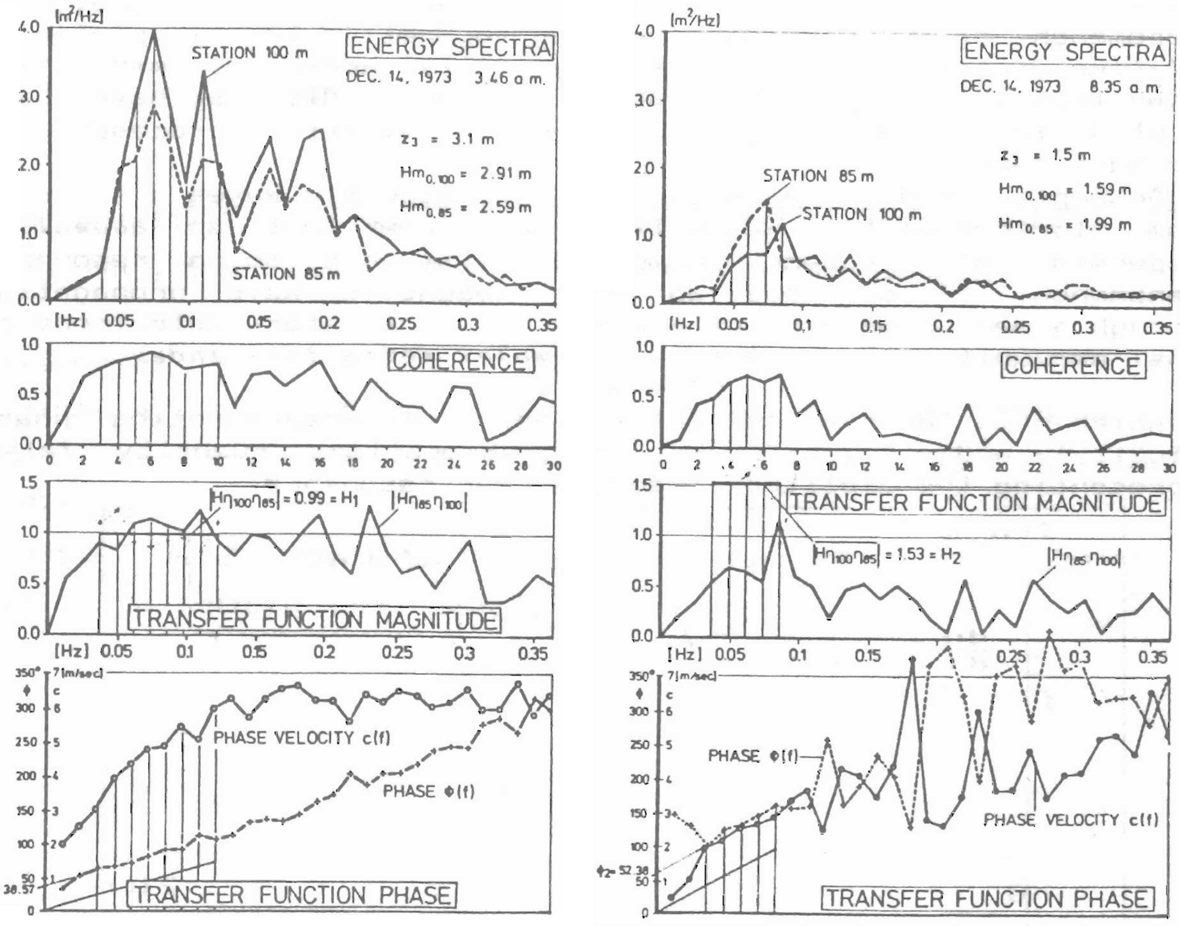
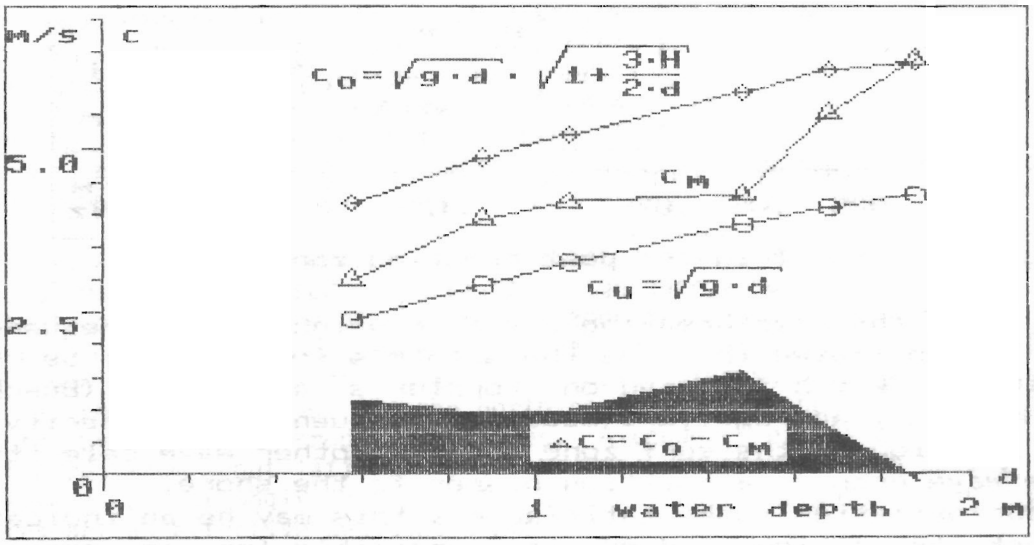


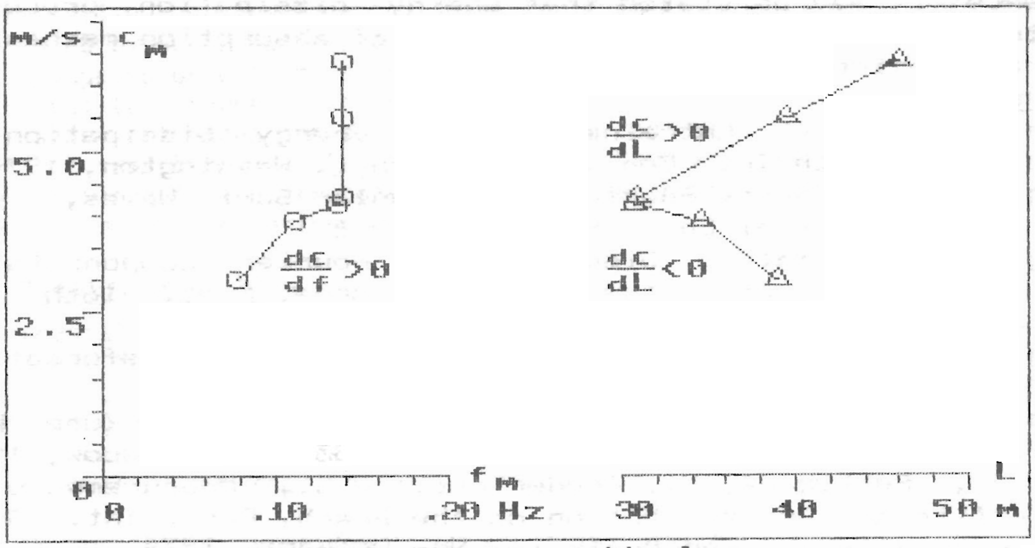
Fig.02/Fig.03: Spectral functions at different tide water levels.

In the upper parts of figures 2 and 3 two sets of synchronously measured energy spectra of water level deflexions are to be seen, both characterizing different wind and water depth conditions at stations 100 and 85 m distant from the shoreline respectively in a coast perpendicular measuring profile on the isle of SYLT/North Sea. The corresponding phase velocity graphs (see lower parts)

obviously in both cases show an anomalous dispersion relationship dc/df > 0 in the whole energy containing frequency range; a frequency shift (red shift) together with an energy increase is, however, present at lower water depths only, see Fig.03.
The later phenomenon, also to be seen from spectra published by Sonu, Pettigrew and Fredericks (1974) and Goda (1975), is interpreted by the author partly as a *resonance phenomenon caused by a backfeed from the periodical backwash action* together with Doppler's spreading effect which is present in the whole spectrum due to the irregular particle movement induced by wave breaking.
The energy decrease of near breaking (not yet broken) waves in Fig.02 can be explained by dominating damping associated with a relaxation process rather than by resonance, see Büsching (1983).
In order to get a better physical understanding some results from time domain data using zero crossing evaluation technics are given in the following graphs:



<u>Fig.04:</u> c_o, c_m, c_u and Δc over water depth



<u>Fig.05:</u> c_m over f_m and L respectively

Measured propagation velocities c_m compared to c_o, see Fig.04, suggest average backwash action as indicated by Δc with a maximum

opposite propagation velocity at the breaking position.
The steep drop of propagation velocity accompanied by a measured constant wave frequency f_m leads to a maximum wave steepness at the breaking point, see Fig.05. After breaking the frequency f_m of the step shaped wave of translation decreases with the consequence of an *anomalous* dispersion property $dc/df > 0$ or $dc/dL < 0$.

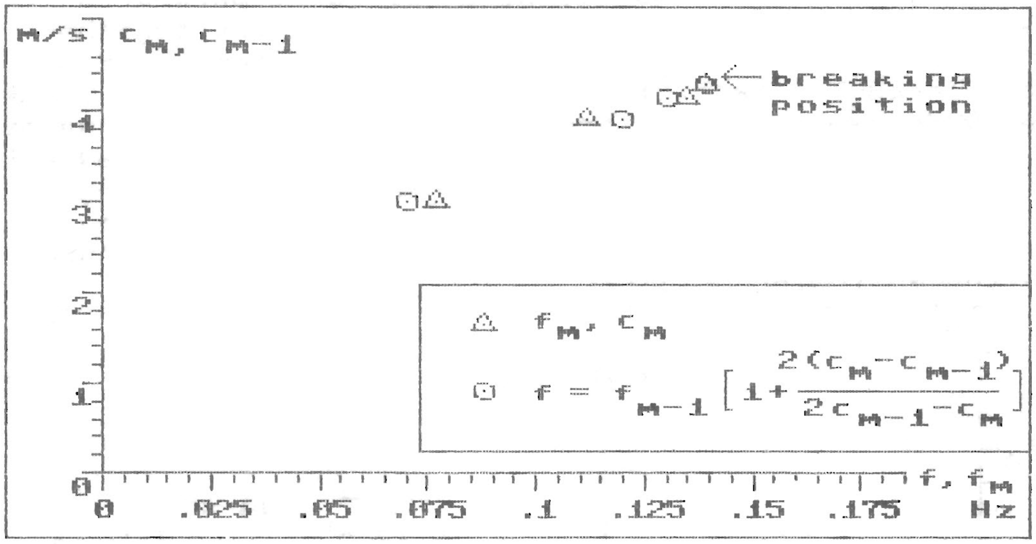


Fig.06: c over f in the post breaking zone

Starting from the wave breaking position neighbouring frequencies can be approximated in using the author's formula, to be seen from Fig.06, which is based on Doppler's principle (Büsching 1980). Here f_{m-1} and c_{m-1} are measured frequency and celerity at a known position in the surf zone and c_m another wave celerity on the same wave beam at a position nearer to the shore.
As the approximation looks satisfactory this may be an indication that back wash action, indeed, is responsible for an anomalous dispersion property to occur in the surf zone, and as a consequence it may be stated that energy dissipation processes can at least partly be dscribed by means of absorption mechanisms known from electromagnetic waves.

4. References

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